BYPRODUCTS UTILIZATION PROGRAM

FOOD IRRADIATION PROJECT

Jacek S. Sivinski and R. Kirk Switzer
CH2M HILL, INC.
6121 Indian School Road, N.E., Suite 206
Albuquerque, New Mexico 87110

ABSTRACT

Food irradiation at doses of 10 kGy (1000 krad) or less have been found by international expert committees to be wholesome and safe for human consumption. Irradiation with cesium-137 can be used as a means of enhancing particular properties of various food commodities by means of sterilization, insect disinfestation, delayed senescence and ripening, and sprout inhibition. Among the topics discussed is the use of low-level irradiation processing to provide trichina-safe raw pork and as a possible substitute for ethylene dibromide fumigation of citrus products for the control of fruit fly and seed weevil infestations. The use of a transportable cesium irradiator as a research tool for full-scale irradiators is also discussed. Some other activities that meet the U.S. Department of Energy objective of promoting commercial application of food irradiation technology are also presented.

INTRODUCTION

Gamma radiation has been used for many years to effect certain desired changes in exposed materials. Approximately 102 irradiators are currently operating in the world sterilizing a variety of medical, pharmaceutical and other miscellaneous products. It is being increasingly recognized that radiation affects many materials in a manner which improves their quality and utility.

History of Food Irradiation

The U.S. Department of Energy (DOE) and its predecessor agencies have long been involved with the technology of utilizing gamma irradiation as a means of enhancing particular properties of various food commodities. Some limited research work was sponsored by the Atomic Energy Commission (AEC) in the early 1950's as part of the Atoms for Peace Program. During this period, major activity was also supported by the Department of Defense (DOD) with the objective of sterilizing foods for military use, thereby eliminating refrigeration requirements. However, concerns regarding the safety and wholesomeness of irradiated foods in the context of the Congressional definition of radiation as a food additive mandated further research. In early 1960, the AEC assumed responsibility for the low dose applications of radiation in extending commodity shelf lives and in insect disinfestation. At the same time, the DOD assumed primary responsibility for high-level radiation sterilization of food with emphasis on pork, beef and chicken.

The AEC program in food irradiation in the 1960's involved economic feasibility studies, basic and applied research supporting wholesomeness petitions to the Food and Drug Administration (FDA), irradiator development, public education and international cooperation. The goal was to foster commercial utilization of the technology. Hearings before the Joint Committee on Atomic Energy were held annually during the 1960's to review the status of AEC and DOD programs.

By 1968, the AEC had investigated low-dose irradiation of several commodities including strawberries, citrus fruits, tomatoes, peaches, grapes and various seafood products. Much of this work was presented in petitions to the FDA for acceptance and appeared favorable from a technical feasibility viewpoint. Several U.S. irradiator facilities were constructed by 1968.

Throughout this period, one of the major impediments to commercialization of food irradiation technology was the FDA position with regard to wholesomeness. The Congressional definition of radiation as a food additive and subsequent FDA regulations implementing the law required a complex series of animal feeding trials of irradiated foods to verify safety and wholesomeness. These lengthy, expensive studies comprised a major part of the FDA petition process. Unfavorable FDA action on several DOD petitions in the late 1960's dampened industry enthusiasm and probably contributed to the demise of AEC efforts in 1971.

Internationally, much research was conducted on food irradiation in the 1950's, 1960's and 1970's. Joint efforts were established in the 1960's between the Food and Agriculture Organization (FAO) and the International Atomic Energy Agency (IAEA). In 1970, an International Project in the Field of Food Irradiation was established involving 25 countries. Continuing research on toxicology and wholesomeness led the Joint Expert Committee on Food Irradiation (JECFI), in 1980, to a conclusion that irradiation was a process rather than an additive and that any food irradiated to a dose of up to 10 kGy (1000 krads) was toxicologically safe for human consumption.

The overwhelmingly negative toxicological results worldwide regarding food irradiation also prompted the FDA to review their position in this area. Their Bureau of Foods Irradiated Food Committee was established to review the data and reported recommendations to the FDA in 1980. Based upon these recommendations, the FDA published a Notice of Intent to revise the policy on irradiated foods (21 CFR Ch.1 dtd. March 27, 1981). The basic proposed changes are to consider foods irradiated to doses less than 1 kGy (100 krads) unconditionally wholesome and safe for human consumption without toxicological evaluation. In addition, certain foods comprising minor portions of the diet may be irradiated to doses up to 50 kGy (5000 krads). A preliminary safety decision tree (Fig. 1) has been proposed by the FDA for doses above 1 kGy (100 krads).

The FDA is currently reviewing the JECFI policy statement that foods irradiated at doses up to 10 kGy (1000 krads) be considered unconditionally wholesome for human consumption. FDA may or may not revise their policy to reflect the view of the JECFI.

Potential Applications of Food Irradiation

Food irradiation can be divided into three categories according to the applied radiation dose: high, medium, or low dose. A high dose is considered to be doses above 10 kGy (1000 krads). A medium dose is considered to be anything between 1 and 10 kGy. A low dose is considered to be anything below 1 kGy (100 krad). High dose applications generally are concerned with commercial sterilization (shelf stability) of a particular food. Medium-dose applications are generally for reduction of microbial load and/or for improved food shelf life. Insect disinfestation, delayed senescence and ripening, and sprout inhibition are some applications that fall into the low dose category.

The technological feasibility and limitations of food irradiation have been established for many important foods. Of the potential applications for food irradiation, some of the most promising include (1) hygienization of spices and other dry condiments now treated with ethylene oxide; (2) reduction of food-borne salmonellae, reducing frequency of salmonellosis (irradiation is the only treatment appropriate for heat-sensitive products, such as frozen chicken); (3) irradiation of tropical and subtropical fruits to prolong storage life and delay senescence; (4) control of insect infestation of citrus products, specifically as a commodity quarantine treatment; (5) irradiation of vegetables to control spoilage and insect disinfestation and for the extension of product shelf life; and (6) irradiation of pork to control trichinosis.

DOE's Food Irradiation Project

The benefits of food irradiation processing include (1) low external energy requirements, (2) a broad range of effective applications, (3) no residual after treatment, and (4) an extensive history of scientific research and safe operating experience.

The objective of DOE's food irradiation project is to promote commercial food irradiation using cesium-137 with emphasis on low-dose applications. Several activities are included in the overall plan to promote commercial application of the technology. They are (1) evaluate the market for various food irradiation applications, (2) support research and development on irradiated food products, (3) support research and development of food irradiator designs, (4) perform an economic evaluation of various food

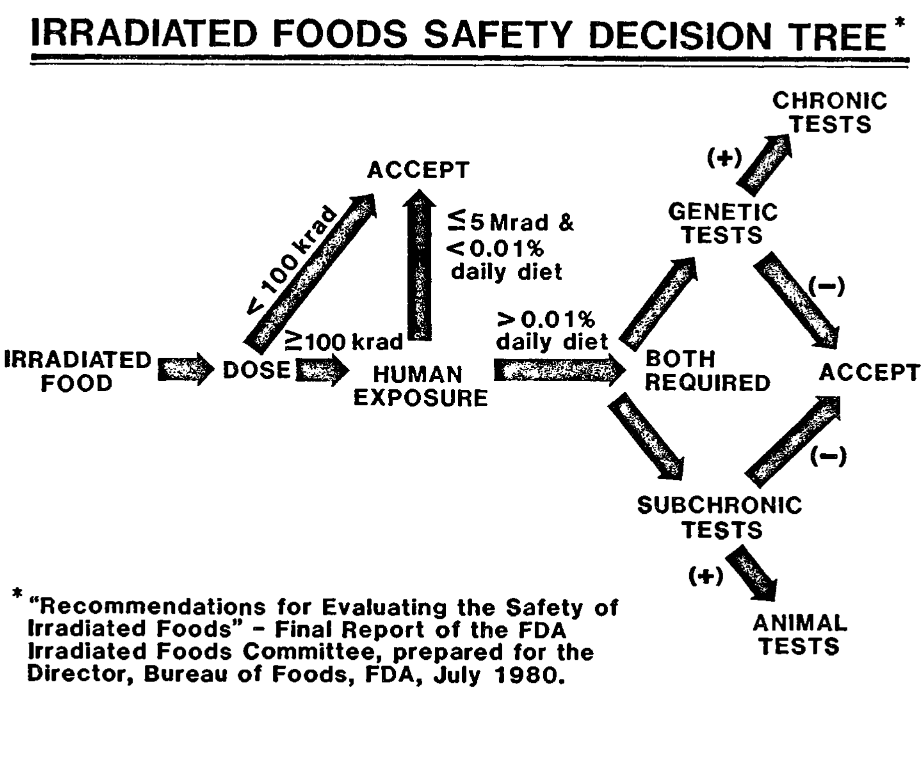

Fig. 1. Irradiated Foods Safety Decision Tree

irradiation applications, (5) support the evaluaton of food irradiation in full-scale irradiation demonstration facilities, and (6) perform technology transfer activities to inform industry and other potential users on food irradiation procedures, economics, and effectiveness.

PORK IRRADIATION PROGRAM

The Trichinosis Problem

The parasitic nematode Trichinella spiralis, the causative agent of pork trichinosis, has long been a blemish on the U.S. public health record. Trichinosis remains a problem in the U.S. today, both as a threat to human health and as an expensive stigma on the U.S. pork industry. Progress in swine management since 1950 has improved the situation, but today the U.S. still has one of the highest rates of trichinosis among the industrialized nations.

About 110,000 infected swine are slaughtered each year in the U.S., yielding 40 million potential meal servings containing the parasite, and infections in 150,000 to 300,000 individuals. Human infection is usually mild or asymptomatic (in 1980 there were 130 serious cases and 1 death), but quite frequent. The last major survey of autopsy data found 4.2 percent of the U.S. population is infected with the parasite.

The underlying reason for the U.S. trichinosis problem is the absence of an inspection program. There is currently no inspection method that can keep pace with the high through-put of the U.S. pork industry. Thus, thorough cooking of fresh pork remains a necessity.

The trichinosis stigma has resulted in a lack of confidence in the U.S. pork industry, both among domestic consumers and in the world market. The effect of this stigma on the industry is avoidance of pork by some consumers and a tendency by others to overcook the product to the point that palateability suffers. The trichinosis problem also retards foreign markets. Some countries, particularly in Europe, have embargoed U.S. pork because of trichinosis, and others importing U.S. pork require certification that the product is noninfectious for trichina.

In this country, certification of pork as trichina-free is currently obtained by three methods: 1) freezing for 2 weeks at 5°F; 2) thorough cooking; and 3) drying and curing with approved additives. There are drawbacks associated with each of these methods. Freezing is currently the only practical method rendering fresh pork noninfectious, but it is an energy-intensive process and it affects palateability. Thorough cooking also affects palateability and it has limited utility for further processing. Additionally, it does not address the fresh pork market. Drying and curing is a lengthy process, involves unpopular additives (sodium chloride salt, nitrites, phosphates), does not eliminate problems associated with microbial growth, and also does not address the fresh pork market.

Potential Control of Trichinosis By Gamma Irradiation

A promising method for rendering pork noninfectious for trichina is gamma irradiation. Extensive research on the irradiation of trichina-infected meat has indicated that the parasitic disease cycle could be effectively broken by relatively low levels of radiation. Most researchers agree that a dose of 0.3 kGy (30 krads) delivered to pork should render fresh pork trichina safe.

The food sterilization program administered by the Atomic Energy Commission and the U.S. Army examined various foods irradiated with much higher doses (10 to 60 kGy, 1000 to 6000 krads). They found them to be generally wholesome, although in some instances they were objectionable in flavor and aroma. Notably, pork and pork products were especially resistant to these effects and were deemed satisfactory, both aesthetically and nutritionally even after doses of 30 kGy (3000 krads). Wholesomeness and toxicity studies were also performed at the lower doses sufficient for inactivation of trichina, and as expected, showed no detectable deleterious effects of radiation. In fact, taste panel results in this work showed that irradiated pork was preferable to the unirradiated samples due to the extended shelf life of the former. This increased shelf life after low doses was reported by several different investigators, and promises to be a marked fringe benefit of trichinosis control with radiation.

Program Plan

Clearly there is a need to reevaluate the great potential for control of trichinosis and certification of pork as trichina-free with low-dose irradiation. A program has been initiated to assess the impact of trichinosis in the U.S. and to assess the potential benefit from a cesium-137-based pork irradiation program.

To meet these objectives the following program has been developed: (1) a detailed assessment of the impact of trichinosis on human health in the U.S.; (2) research to verify the radiation control of trichinosis under conditions that simulate the modern pork industry; (3) a logistic and economic feasibility study of a large-scale pork irradiation program; and (4) publication of findings.

Research Program

The pork irradiation research program has two objectives. First, is to determine the radiation dose required to certify pork as "trichina-free". Second, is to determine the effects of irradiation on various properties of marketable pork and pork products. These properties include shelf life, wholesomeness, and organoleptic properties.

Work on verification of dose requirements has been performed in the gamma irradiation facilities at Sandia National Laboratories (SNL) in Albuquerque, New Mexico. Participants in the research program include the DOE, the Los Alamos and Sandia National Laboratories, the USDA Animal Parasitology Institute, the Inhalation Toxicology Research Institute, New Mexico State University, Iowa State University, the National Pork Producers Council and CH2M HILL.

Ground-pork samples and split-half hog carcasses have been irradiated in the dose-verification experiments. The irradiator facilities were modified to accommodate irradiation of the hog carcasses. Three cesium-137 pins of approximately 60 kCi each were arranged to provide dose rates in the range needed for slaughterhouse application.

Results of the ground-pork experiments show that almost all first-generation larvae are inactivated at a dose of 0.2 kGy (20 krads). Complete inactivation was achieved at 0.3 kGy (30 krads). Inhibition of production of second-genration muscle larvae was essentially achieved at 0.1 kGy (10 krads). This inhibition of reproduction is the prime objective of the radiation treatment, however a 0.2-kGy (20-krad) dose also inhibits, to a significant degree, the maturation of the encysted larvae in the infected pork.

Past research on cobalt-60 irradiation of whole hog carcasses shows that a dose of 0.11 kGy (11 krads) is effective in complete sterilization of female trichinae. Preliminary results of split-half hog carcass irradiation under the current DOE research program show that first- and second-generation larvae are also eliminated at low-dose levels. Research is continuing to verify the preliminary data.

Pork Irradiation Feasibility

The research program outlined above is demonstrating the technical feasibility of irradiating pork. However, for irradiation technology to be accepted and implemented on a commercial scale, it must also be economically, financially, politically, and socially feasible.

The project is economically feasible if the benefits resulting from it exceed the costs, and there is no cheaper method of accomplishing similar results. The test of financial feasibility is passed if sufficient funds can be raised to pay project construction and operating costs. The project is politically feasible if the required approvals can be secured, such as from the FDA. Finally, the test of social feasibility is passed if the potential users (consumers) respond favorably to the product. These tests of feasibility are interrelated, but each must be passed individually if a project is to be successful.

A study to determine the overall feasibility of a commercial-scale, pork irradiation program is one of the current activities under the DOE food irradiation project. Although the study has not been completed, some preliminary generalizations may be stated regarding the effect of irradiation on pork demand and on the social and political feasibility.

Consumer attitude and market studies have shown that the trichinosis stigma reduces the potential pork demand in both the domestic and foreign markets. Although there is a lack of conclusive data on consumer acceptance of food irradiation, it is likely that elimination of trichinosis would result in an increase in the domestic demand for pork. Because several foreign countries only permit the importation of pork that has been certified "trichina-free", the U.S. share of the foreign market would also be expected to increase as a result of an irradiation program.

There do not appear to be any insurmountable obstacles from the viewpoint of social feasibility. Detailed consumer acceptance studies should be undertaken on the influence, if any, of the required doses of irradiation on the appearance, taste, and texture of pork and pork products.

There do not appear to be any insurmountable obstacles from the viewpoint of political feasibility. It is likely that the FDA will designate food irradiated at doses of 1 kGy (100 krad) or less as wholesome and safe for human consumption. The decision on whether the products must be labelled as irradiated may have an important influence on consumer acceptance.

Issues in need of further study include: (1) developing reliable estimates of the demand for irradiated pork in both domestic and foreign markets (including the potential for beef and poultry substitution); (2) determining the adequacy of transportation facilities for increased exports (such as number of refrigerated vessels); (3) assessing packer/ processor interest and developing an implementation program; (4) analyzing the economics of small scale irradiators; (5) confirming the potential benefits from reduced spoilage; and (6) assessing other potential benefits and costs (such as from reduced use of additives).

Work is continuing under the Byproducts Utilization Program to determine the economic and financial feasibility of a pork irradiation program.

Pork Demonstration Facility

To promote the commercial application of irradiation to the pork industry, it is important to demonstrate the technical feasibility of a pork irradiation program using existing technology. Construction and operation of a demonstration-scale irradiator for pork products could be carried out under the auspices of USDA or perhaps a university where there are significant swine-production and pork-processing-related research programs. The research support facilities could also conveniently provide unbiased verification of the efficacy of irradiator design and dose level in disinfestation of pork products. Such third-party verification would be essential to domestic and world market consumer acceptance of a product treated by a commercial irradiation facility.

Preliminary designs for a pork irradiator have dealt with the irradiation of the whole, slaughtered hogs. The pork carcass is not geometrically symmetrical nor is it homogeneous. A demonstration facility would be designed to establish the optimum cesium-137 source configuration and arrangement of the materials-handling systems which could be used to expose the hog carcasses to a uniform dose from the source.

The economic importance of certifying pork "trichina-free" by irradiation on a commercial scale in both domestic and international markets was discussed earlier. Reliable estimates of current capital costs for a demonstration irradiator have not as yet been developed, but are a significant factor in the economic analysis of the technology. A demonstration facility would validate capital and operating costs for the irradiation treatment process. The facility would be invaluable for research and development, as a site for technology observation by the industry, and as an operator training and design refinement facility for subsequent irradiators constructed by and for the pork industry.

CONSUMER AND INDUSTRIAL ACCEPTANCE

Consumer and industrial acceptance of food irradiation technology are two areas of vital concern to successful transfer of the technology. Consumer acceptance is broken down into two major areas. The first is the concern of the safety of an irradiated product, and the second deals with the perceived value to the consumer of the irradiation process.

In dealing with the safety issue, it is very apparent that a great deal of misconception lies in the minds of many consumers. An educational program separating irradiation as a process from the nuclear industry must be initiated. The public must be made aware of the acceptance of this technology in many other areas of daily life, such as in the medical products industry, the coatings and wrappings industry, vulcanization in the wire insulation and automobile tire industries, and in the radiopharmaceutical and radiomedicine areas. Once the consumer understands that radiation is a very natural and commonly used technology, acceptance will be based more on the second area of consideration.

This second area deals with the perceived value of the technology to the consumer. In some cases, such as citrus irradiation, the value lies much farther upstream in the food production cycle than the supermarket where the consumer meets the product. Two examples can be sited to demonstrate these points. The first is concern with citrus irradiation as a means of protecting agricultural areas from introduction of agricultural pests of significant economic importance. The typical consumer is probably not aware of the treatment processes, quarantine procedures, embargos, non- tariff barriers, etc. which impact these kinds of activities. Therefore, he has little grounds on which to make a rational choice when choosing irradiated citrus versus non-irradiated citrus in the supermarket. On the other hand, when he can choose a pork product that is certified "trichina-safe" with ionizing energy, he has much better grounds for making a decision for or against the irradiated product. The typical consumer is very much aware of the trichinosis problem and the value of certified "trichina-safe" pork is immediately apparent to him.

Industrial acceptance, on the other hand, deals much more with economics and with the introduction of a new technology when a capital investment has already been made in existing packing, processing, and storage facilities. Before the industrial sphere can even consider a change in a technology, a very valid and pressing reason to change must be provided. Decreased costs, improved efficiency, improved consumer acceptance, better profits, a more secure segment of the market, and an enhanced competitive position are the kinds of reasons that drive a change in the processing industry.

QUARANTINE TREATMENT FOR INSECT INFESTATIONS

Irradiation for insect disinfestation is being investigated as an alternative to fumigation with ethylene dibromide (EDB), a suspected carcinogen currently scheduled to be banned by the EPA from further use as of July 1, 1983. A scenario was developed that examines the replacement of EDB fumigation capabilities for the State of Florida with gamma irrdiation using cesuim-137.

Citrus is currently fumigated with EDB for disinfestation before shipment to foreign markets and some domestic markets. Disinfestation entails parking a semitrailer of citrus in a chamber for a fumigation cycle of 3 to 4 hours. Following fumigation, the semitrailer is removed from the chamber and hauled to a warehouse at dockside. Currently, the cost for disinfestation is $0.06 per carton.

The preliminary study indicates that current fumigation capacity in Florida could be replaced with four irradiators, each with the capacity of irradiating an average of 2 million lb/day to a minimum of 0.25 kGy (25 krads) absorbed dose with a min/max ratio of 0.7. The pallets loaded with the standard export carton would be unloaded from the trucks at the irradiator site, disbanded, conveyed into the irradiator by the carton, irradiated, unloaded, repalletized, rebanded, and reloaded onto the truck. The total cost for irradiation treatment is about $0.15 per carton. This compares with a cost of $0.06 per carton using fumigation facilities. A conversion to irradiation would cost an additional $0.0014/lb of fruit processed.

The preliminary cost estimates used in the scenario are made without detailed engineering data. Because the estimates are generic rather than site specific, confidence limits on these preliminary estimates cannot be developed.

USDA research to date has generally shown that (1) at doses greater than 0.3 kGy (30 krads) phytotoxic effects appear greater in irradiated grapefruit than in controls; (2) absorbed doses of at least 0.15 kGy (15 krads) appear to provide an adequate lethal sterilizing dose to eggs, larvae, pupae and adult Carribean fruit flies (a dose of 0.06 kGy [6 krads] is probably adequate for sterilization of adults and larvae); (3) no significant changes were detected in several organoleptic properties when fruit was irradiated at doses up to 0.9 kGy (90 krads); and (4) in general, grapefruit harvested early in the season appeared most susceptible to radiation-induced flavor degradation and phytotoxic effects.

Irradiation has been the subject of much research as a possible quarantine treatment of citrus fruit. The USDA/ARS believes that the study of irradiation as a potential replacement for EDB is both timely and prudent. USDA research on irradiation is therefore in progress. The USDA Animal and Plant Health Inspection Service (APHIS) acknowledges that irradiation is a potential alternative to EDB, but feels that its practical application must be proven before it will accept the process as a relacement for EDB fumigation.

A full-scale process demonstration facility is needed to meet the following objectives: (1) evaluate the technical feasibility of full-scale irradiation; (2) develop the mechanics of product handling; (3) accurately determine treatment costs; and (4) assess and modify irradiator design for further citrus industry utilization. Demonstration results will establish the process that provides maximum treatment efficacy and minimum costs. The technology transfer strategy for cesium food disinfestation recognizes the uniquely different aspects of Florida citrus fruit handling, packaging, and shipping techniques versus the techniques used for California fruits and vegetables. A full-size irradiation demonstration facility could be used in both states.

TRANSPORTABLE CESIUM-137 IRRADIATOR

Research data is needed to confirm the efficacy of irradiation treatment for commodities subject to infestation by pests of quarantine importance. Consequently, irradiation treatment research has been ongoing for many years at a few fixed sites. One of the greatest needs in irradiation research is a mobile irradiation unit that can be located onsite with the appropriate industry rather than shipping the agricultural commodities great distances to existing irradiation facilities.

Some of the advantages of a mobile unit include: (1) working under the specific needs of the local situation with various commodities; (2) avoiding experimental anomalies such as loss of temperature control, loss of humidity control, long storage periods, delays before and after exposure to irradiation, and other handling problems; (3) gaining industry support through first-hand observation; (4) working with standard "unit" packaging of various agricultural industries; (5) flexibility--opportunity to work with several commodities of interest (Florida citrus, Washington and Oregon apples, Florida tropical fruits, Florida strawberries, Florida ornamentals, Washington cherries); and (6) being at the right place at the right time with regard to fruit maturity, market, specific packing houses, and at critical points in the handling, storage, and packaging of the various commodities.

The timely design and construction of a transportable cesium-137 irradiator is an important part of achieving commercial application of irradiation as a disinfestation method for certain fruits and field crops. Lack of data for specific crops will do little to encourage private investment in full- scale irradiators. However, availability of a test facility to develop dosage requirements and other data onsite will increase the accuracy of the economic analysis. It will also increase investor confidence in building new facilities to support cesium-137 irradiation technology. Because of the significance of these implications, CH2M HILL was authorized to execute a predesign study for a mobile irradiation unit to meet these agricultural commodity needs.

The predesign report concludes that the concept of a TransPortable Cesium-137 Irradiator (TPCI) is feasible to design, build, and operate. The proposed predesign of TPCI meets the required objectives of source size, irradiation dose, transportability, and safety considerations.

A cesium-137 source consisting of Waste Encapsulation and Storage Facility (WESF) capsules will be transported and stored in a previously licensed shipping cask: the NRBK-43. The cask and source will be contained in the source chamber of the irradiator where the source is raised from the cask to allow product irradiation.

The product will be placed in a revolving drum-shutter configuration for irradiation. The radiation time and distance from the source may be changed to achieve the desired product dosage. Environmental controls will maintain the desired product temperature and atmosphere during irradiation.

The TPCI irradiator unit, shielded with lead, will be mounted on a specially designed trailer and can travel on Class-I-designated highways in most of the United States. The cesium source transportation cask will be shipped separately using a contract trucking company or a vehicle dedicated to the transportation of the cask and any needed support systems or equipment.

IRRADIATION OF ALGAE FOR FEEDSTUFF PRODUCTION

Algae has been recognized as a good primary feedstuff for nonruminant animal production because they contain protein, carbohydrates, and other nutrient constituents.

Algae are especially desirable as poultry feed because of their high lysine and protein content. Poultry require 15 to 25 percent protein in their daily ration, and lysine is a particularly important component. Because poultry cannot synthesize lysine, it must be supplied in their feed. Therefore, there is a potential for marketing this material at a dollar value greater than soybean meal.

Fish production is another algae feeding application. It has yet to be investigated and developed in this country to the extent it has with poultry and livestock. However, it is a particularly interesting and attractive application due to the high efficiency of protein production by fish for the feed consumed.

Algae is an attractive and acceptable source of protein for animal feed when agricultural wastes such as feedlot or dairy wastes are used for their production. However, when the concept of producing feedstuff from algae grown on human waste is proposed, problems regarding acceptability, whether real or perceived, may arise. The principal valid concern involves algae contamination by pathogenic microorganisms from the wastewater.

Irradiation treatment of the algae with cesium-137 can be used as a process to safely reduce these pathogen levels. This is analagous to the process of irradiating wastewater sludges to eliminate pathogens before refeeding sludge to ruminants. Irradiation used in this way permits the safe introduction of a product, grown on human waste, into the human food chain. The complete cycle can be described as follows: Human waste enters the treatment facility where algae are produced. Algae are harvested, dried, and irradiated with cesium-137; feedstuff is produced from the algae and fed to various animals (swine, poultry, fish); these animal food products are consumed by humans who, in turn, contribute waste products to the sewage treatment facility.

AID/DOE

The U.S. Agency for International Development (AID) has recognized that reduction of post-harvest losses has a significant impact on the availability of food in the emerging nations. Because of the long history of research programs in these countries sponsored by the developed nations mainly through the International Atomic Energy Agency (IAEA) and the Food and Agricultural Organization of United Nations (FAO), there is both an awareness and enthusiasm for food irradiation as a significant step in reduction of post-harvest losses in these countries.

The AID in conjunction with the DOE is evaluating the potential impact of food irradiation technology in various countries. The preliminary findings indicate that assistance in bringing this technology to emerging nations will benefit both the developed and developing countries. To this end, the AID is conducting an initial investigation into a program which would implement at least one regional research center for the support of the required research, the training of food irradiation specialists, determination of the economic implications of irradiation in increasing the food supply, and the potential for international trade improvement. If warranted by the results of this preliminary investigation, it is anticipated that a joint effort with the DOE will be initiated in the near future.

MILESTONES FOR THE FOOD IRRADIATION PROJECT

DOE has established milestones for several cesium-137 food irradiation applications.

A joint venture agreement for a pork irradiator is planned for late 1983. The irradiator is expected to be in operation by late 1984.

A citrus irradiator is also being planned with a joint venture agreement expected by late 1983, and the irradiator operational by the end of 1985.

The TPCI research irradiator is scheduled for startup by the end of 1983.

An agreement for a DOE/AID foreign food irradiator is expected to be in place late in 1983.

SUMMARY

Irradiation of food is rapidly becoming an acceptable technique for disinfestation and preservation. In fact, with the present concerns about the use of potential carcinogens for fumigation of food (e.g., EDB), irradiation may become the preferred technique for many applications.

It appears that irradiation may be useful for the treatment of many field crops and other foods. Adequate testing can best be accomplished with a transportable cesium irradiator (TPCI). For fruits and field crops, the dose required and any seconary effects, such as changes in texture and taste, can be tested effectively only at the harvest site. A promising preliminary design enabling separate transport of the irradiation chamber and the cesium-137 source has been completed.

Successful commercialization of food irradiation technology depends on its acceptance in the marketplace. As with other new food processing techniques, introduction of food irradiation may involve overcoming processor and consumer resistance to a new technology. Consumer acceptance of irradiated foods will probably depend on thoughtful consideration of at least three important areas: safety for consumption, organoleptic qualities, and value (including cost) for the consumer.

The use of food irradiation as a resource conservation measure is particularly applicable to the problem of world hunger. The U.S. AID in conjunction with DOE is investigating this technology for prevention of food loss, a measure that has significant potential for developing countries.

There are two major perceived differences between irradiation and conventional food treatment processes: irradiation is new to the consuming public, and it is related to the nuclear industry if the radiation source is a radionuclide. The implications of these two facts must be openly addressed by the food industry and the government. Though other countries are beginning marketing programs for irradiated food, the availability of plentiful, affordable alternatives may limit the U.S. consumers' demand for irradiated products. Issues of food quality, food safety, and food pricing for irradiated products, alternatives for toxic chemical usage and consumer understanding of irradiation's benefits, will be required for successful U.S. adoption of the technology.

BIBLIOGRAPHY

CH2M HILL, An Update on Food Irradiation Technology in the United States, April, 1982.

CH2M HILL, Byproduct Utilization Program--Cesium-137 Research and Technology Transfer Activities, June, 1982.

CH2M HILL, EDB and Its Atlernatives for Florida Citrus Quarantine--Current Status Report, December, 1982.

CH2M HILL, Report on Feasibility of Irradiating Pork to Control Trichinosis (Review Draft), December, 1982.

CH2M HILL, TransPortable Cesium Irradiator--Predesign Report, November, 1982.

Josephson, Edward S. and Martin S. Peterson, eds., Preservation of Food by Ionizing Radiation, Vol. II, CRC Press, Boca Raton, Florida, 1983.

McMullen, W. H. and J. G. Yeager, eds.; Workshop on Low-Dose Radiation Treatment of Agricultural Commodities--Working Report, DOE/USDA/AIBS, April, 1982.

Sivinski, Jacek S., Environmental Application of Cesium-137 Irradiation Technology: Sludges and Foods, presented at the Fourth International Meeting on Radiation Processing, Dubrovnik, Yugoslavia, October, 1982.

U.S. Department of Energy, Department of Energy Plan for Recovery and Utilization of Nuclear Byproducts from Defense Wastes--Executive Summary, January, 1983.